Smooth pond-like deposits on asteroid 4 Vesta: Preliminary results from the Dawn mission. H. Hiesinger[1], O. Ruesch[1], R. Jaumann[2], A. Nathues[3], C. A. Raymond[4], and C. T. Russell[5], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (hiesinger@uni-muenster.de), [2]DLR-Inst. für Planetenforschung, 12489 Berlin, Germany, Max-Planck Institut für Sonnensystemforschung, 37191 Katlenburg-Lindau, Germany, [4]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA, [5]Univ. of California Los Angeles, Inst. Of Geophysics, Earth, and Space Sciences, Los Angeles, CA 90095, USA.

Introduction: Asteroid 4 Vesta is the second largest asteroid and is currently being investigated by the Dawn spacecraft. Vesta is of particular interest for our understanding of early solar system processes because it is most likely a fully differentiated planetesimal [1] that survived subsequent collisions and thus allows us to look back to the earliest phases of planet formation. Evidence for Vesta being differentiated comes from more than 900 HED (howardite-eucrite-diogenite) meteorites, which presumably originate from Vesta [e.g., 2-6]. Such a link between Vesta and the HED meteorites is supported by multispectral observations as well as dynamical considerations [7,8]. Launched in 2007, Dawn arrived at Vesta on July 16, 2011 to study the asteroid with three instruments, including the German Framing Camera (FC), the Italian Visible & Infrared Spectrometer (VIR), and the American Gamma Ray and Neutron Detector (GRaND). While there have been numerous observations from Earth and the Hubble space telescope [e.g., 9,10], Dawn provides the first high-resolution data from its survey orbit, high altitude mapping orbit (HAMO), and low altitude mapping orbit (LAMO). The inspection of FC data revealed smooth pond-like deposits of ambigious origin, similar to deposits on other asteroids such as Eros and Itokawa [11,12]. In principle, several scenarios for the origin of these deposits seem plausible and can be tested with Dawn data, including volcanism, impact sedimentation, impact melt deposition, dust levitation and transport, seismic shaking, or landslides.

Data and Methods: For our investigation of smooth pond-like deposits on Vesta, we used a mosaic of HAMO images with a resolution of ~70 m/pixel. The images were map-projected to a 2-axis ellipsoid with a major axis of 285 km and minor axis of 229km. Such an ellipsoid is the best approximation of most of Vesta's irregular shape (~8% dynamic range w.r.t. ellipsoid) [13].

Results: We measured 83 small (~7 km^2 average size) smooth deposits distributed across the surface of Vesta (Fig. 1, 3). While most ponds on Vesta occur at the floors of impact craters of varying sizes, some of the ponds are located in small irregular depressions. One smooth deposit occurs on top of a cone-like flat-topped hill. We did not observe inflow of material into the depressions, suggesting an internal source of the smooth deposits.

At HAMO spatial resolution, most of these deposits occur as ponds with well-defined geological contacts that indicate that they are younger than the surrounding terrain. However, lunar impact melt pools formed contemporaneously with the surrounding ejecta blankets show similar stratigraphic relationships.

In some cases the albedo of these ponds is lower than the surrounding terrain, in other cases the ponds are indistinguishable from the adjacent terrain. The ponds are not randomly distributed across the surface but preferentially occur in a band between -10 and 30 degrees latitude with fewer ponds north of ~30 degrees and even fewer ponds in the southern hemisphere, i.e., the Rheasilvia region (Fig. 2). The largest cluster of ponds occurs in the vicinity of the so-called snowman impact craters. However, poor lighting conditions and the limited image coverage in the

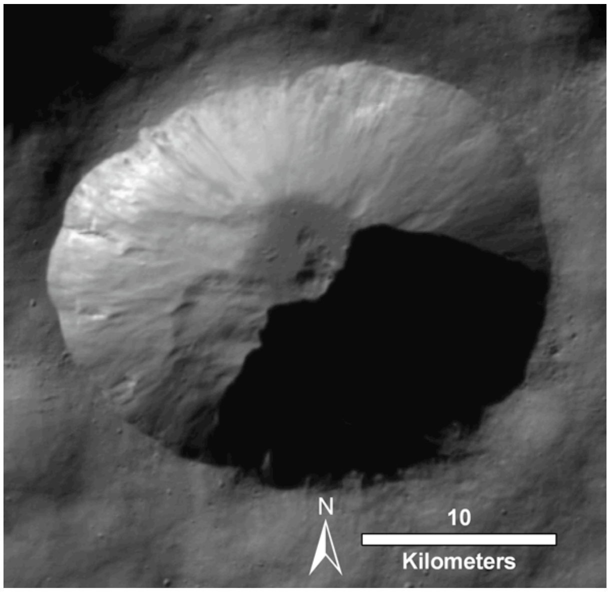

Fig. 1: Example of a smooth pond-like deposit on the floor of an unnamed impact crater on Vesta.

northern hemisphere might bias the observed distribution of smooth ponds.

Discussion: Similar, but smaller (<230 m diameter) smooth ponds were also reported from the surface of asteroid Eros [11]. Robinson et al. [11] found that most smooth ponds on Eros occur in equatorial regions and concluded that the most likely process for their formation is electrostatic levitation and redistribution of the finest regolith components (<100 μm). Sierks et al. [14] argued that along the terminator, particularly strong electric fields can develop between the sun-lit and shaded areas, for example within craters, resulting in particle motion from sun-lit to dark regions. Dust levitation and transport was also discussed for asteroid 25143 Itokawa [12].

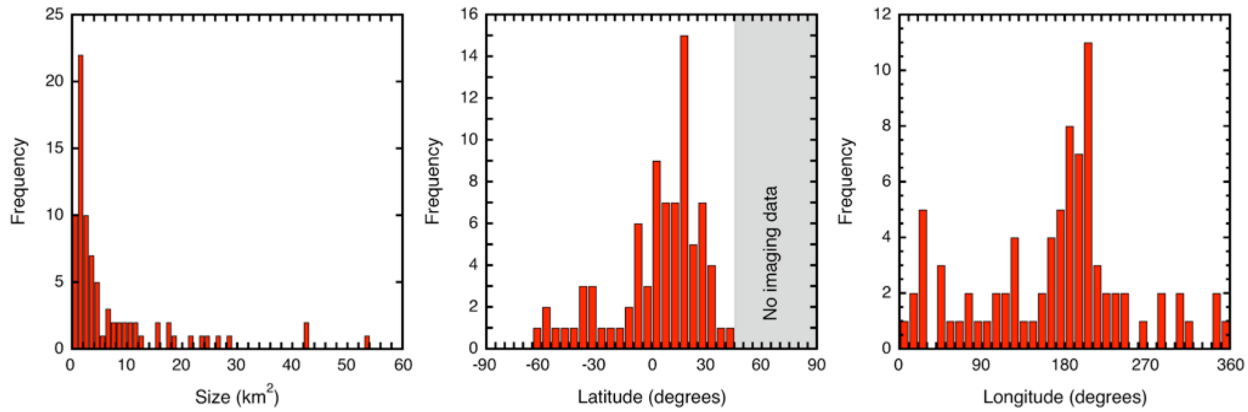

Fig. 2: Histograms of 83 smooth deposits showing their sizes (left) and their latitudinal (center) and longitudinal (right) distribution.

References: [1] Keil (2002), Asteroids III; [2] McSween et al., (2010), Space Sci. Rev., 10.1007/s11214-010-9637; [3] McCord et al. (1970), Science 168; [4] Binzel et al., (1997), Icarus 128; [5] Gaffey, (1997), Icarus 127; [6] Pieters et al., (2005), Proc. IAU Symp. 229; [7] Burbine et al., (2001), Meteorit. Planet. Sci. 36; [8] Cruickshank et al., (1991), Icarus 89; [9] Binzel and Xu (1993), Science 260; [10] Thomas et al., (1997), Science 277; [11] Robinson et al., (2002), Met. Planet. Sci., 37; [12] Yano et al., (2006), Science, 312; [13] Jaumann et al., (2012) submitted to Science; [14] Sierks et al., (2011), Space Sci. Rev., doi:10.1007/s11214-011-9745-4.

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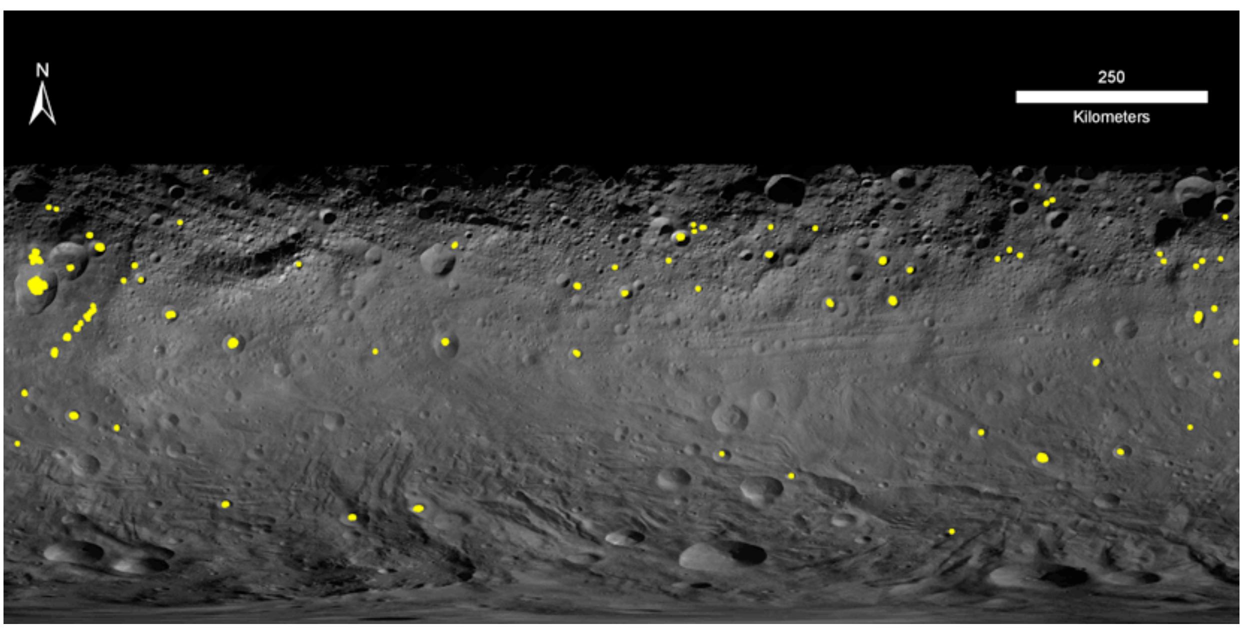

Fig. 3. Mosaic of HAMO images with superposed locations of smooth pond-like deposits.